SITE INFORMATION

Identifying Information

Site Name: Seymour Recycling Corporation Superfund Site
Location: Seymour, Indiana

CERCLIS ID No.: IND040313017

Record of Decision (ROD) Date: September 30, 1987

Treatment Application [17]

Type of Action: Remedial

Technology: Soil Vapor Extraction

EPA SITE Program Test Associated With Application? No

Period of Operation: June 1992 to Present (Report covers period of June 1992 through 1996)

Quantity of Material Treated During Application: 200,000 cubic yards of soil, based on an area of 12 acres and a depth of 10 ft.

Background Information [1, 2, 9]

Waste Management Practice that Contributed to Contamination: Improper waste management practices

Site History: From 1970 to early 1980, the Seymour Recycling Corporation (SRC) and its corporate predecessor, Seymour Manufacturing Company, processed, stored, and incinerated chemical wastes at the Seymour site. The site, which occupies about 14 acres, was closed when SRC failed to meet a 1978 agreement with the State of Indiana to cease receiving wastes and to institute better waste management practices.

In 1980, the site was placed under receivership by a state court. In 1981, the U.S. Environmental Protection Agency (EPA) fenced the site to restrict access, constructed dikes to control site runoff, installed an on-site carbon adsorption unit to treat surface water, and sampled on-site soil and the contents of on-site drums and tanks.

In 1982, EPA signed a Consent Decree with a small group of Potentially Responsible Parties (PRPs) to complete "surface cleanup" at the site. Surface cleanup activities, conducted by Chemical Waste Management (CWM) between December 1982 and January 1984, involved the removal and disposal off-site of all wastes stored at the ground surface, including about 50,000 drums and 100 storage tanks. Contaminated soil was excavated from about 75 percent of the site to a depth of 1 foot. In addition, contaminated soil was excavated to a depth of 2 feet from a drum crushing pad area that had been constructed during cleanup activities. The excavated soil was disposed off-site. The site was backfilled with clean fill and covered with a protective clay cap.

Shallow groundwater from the site flows towards a nearby farm and the Snyde Acres subdivision, which has about 100 residences. EPA entered into agreements in 1982 and 1983 with additional PRPs to establish funds for extending Seymour's municipal water system to the farm and Snyde Acres subdivision. This extension of the water system was performed in 1985.

Regulatory Information [3, 11]

On September 9, 1983, the site was listed on the Superfund National Priority List (NPL).

In September 1986, EPA and the Indiana Department of Environmental Management (IDEM) prepared a ROD for the Seymour site that specified an interim groundwater pump-and-treat system to treat groundwater at the site. On September 30, 1987, a second ROD was signed that outlined a comprehensive site cleanup. In December 1988, a Consent Decree outlining the Seymour site remedial

SITE INFORMATION (CONTINUED)

design/remedial action (RD/RA) cleanup was signed by EPA, IDEM, the City of Seymour, and approximately 150 PRPs. The PRPs are represented by the Seymour Site Trust.

Remedy Selection:

The second ROD (September 1987) for Seymour identified the following remedial actions:

- Implementation of a full-scale soil vapor extraction (SVE) system
- In situ bioremediation of soils
- Groundwater extraction and treatment by air stripping (an expansion of the interim system specified in the 1986 ROD)
- Mixed-media capping
- Excavation of 800 yds^3 of contaminated creek sediment and consolidation of the sediment beneath the cap
- Deed and access restrictions and other institutional controls

According to the ROD, the use of a cap and operation of SVE would be useful in preventing leaching of contaminants from the soil to the groundwater, preventing direct contact with contaminated soil, and preventing run-off of contaminated water or sediment. The ROD also indicated that SVE was expected to reduce substantially the concentrations of volatile organic compounds (VOCs) in the unsaturated soils, and that, by including SVE, the selected remedy would be more protective of human health and the environment than a similar remedy without SVE.

The remedial action at Seymour consists of two response actions, one for groundwater and one for the source area. The response action for contaminated groundwater is identified as Operable Unit 1 (OU 1) and for the source area as OU 2. This report is focused on the SVE application at the site. Limited information about the design, operation, performance, and cost of the groundwater cleanup system is provided in this report to present a context for the SVE application.

Site Contacts

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MATRIX DESCRIPTION

Matrix Identification

Type of Matrix: Soil

Contaminant Characterization [1, 2, 3, 9]

Primary Contaminant Groups: From August 1983 to May 1986, EPA performed a remedial

MATRIX DESCRIPTION (CONTINUED)

investigation (RI) at the site. Major RI results are summarized below.

- On-site soils at various depths were contaminated with hazardous organic and inorganic compounds. More than 35 organic compounds were identified, including relatively high concentrations of 1,1,2-trichloroethane (TCA); benzene; vinyl chloride; carbon tetrachloride; 1,1,2,2-tetrachloroethane (PCA); and trichloroethene (TCE). Concentrations of VOCs detected in on-site soils ranged from 10 milligrams per kilogram (mg/kg) to greater than 1,000 mg/kg.

- During the RI, shallow groundwater located at 6 to 8 feet below ground surface (bgs) was found to be contaminated with several organic compounds including chloroethane; tetrahydrofuran; 1,4-dioxane; 1,2-dichloroethane; benzene; vinyl chloride; and 1,1,1-TCA. Subsequent sampling determined that tetrahydrofuran and 1,4-dioxane had migrated about 3,900 feet north-northwest of the site boundary.

- The deep aquifer located at 55 to 70 feet bgs is separated from the shallow aquifer by a silty clay aquitard. As of 1994, continued monitoring of the deep aquifer showed trace levels of site-specific compounds; however, these compounds do not appear to have migrated off site.

- Sediment in the nearby northwest drainage ditch area was contaminated with VOCs but at concentrations of less than 10 mg/kg.

Table 1 summarizes the highest average VOC concentrations in on-site soils above the water table (1.5 to 6.0 feet bgs), as measured during the 1986 RI. The ROD indicated that there were an estimated 200,000 lbs of VOCs present in the soil at the site.

Table 1: On-Site Soil Contaminants and Concentrations [1]

Contaminant	Maximum Concentration (mg/kg)
Benzene	1.4
Carbon tetrachloride	280
Chloroform	15.5
1,2-Dichloroethane	0.0064
Hexachlorobenzene	0.43
Hexachloroethane	5.5
PCE	37
1,1,2,2-PCA	120
TCE	420
1,1,2-TCA	95

Matrix Characteristics Affecting Treatment Cost or Performance [1]

The key matrix characteristics that affect cost or performance for this technology, and the values measured for each, are provided below in Table 2. Hydrogeologic conditions at the Seymour site included the following: a shallow water table (1.5 to 6.0 feet bgs) that flows primarily north and northwest, a complex distribution of soil types, and low air permeabilities in the soil. As discussed later, use of a clay cover allowed for extraction of a relatively large amount of VOCs.

MATRIX DESCRIPTION (CONTINUED)

Table 2: Matrix Characteristics [1, 18]

Matrix Characteristic	Value
Soil Classification	Information not provided
Clay Content and/or Particle Size Distribution	Sands, silts
Moisture Content	Information not provided
Air Permeability	Medium to high
Porosity	Information not provided
Total Organic Carbon	Information not provided
Nonaqueous Phase Liquids	Not observed

DESCRIPTION OF THE TREATMENT SYSTEM

Primary Treatment Technology

SVE

Supplemental Treatment Technology

Activated carbon adsorption
In situ bioremediation
Multimedia cap

System Description and Operation

System Description [1, 2, 17, 18]

The remediation system for contaminated soil at Seymour consisted of the following:

- Construction and operation of a SVE system using horizontal wells
- In situ bioremediation of soils
- Construction of a multi-media cap over the SVE system

The SVE system was constructed at Seymour between July and October 1990. The system consisted of 19 horizontal vapor extraction wells, 11 horizontal air inlet wells (passive), a vacuum blower, a moisture separator, and an activated carbon adsorption system. Approximately 12,700 linear feet of horizontal vapor extraction piping (laterals) were installed about 30 inches below grade. The piping was installed on a bed of compacted sand and buried with a minimum of 8 inches of sand compacted using a mechanical hand tamper. The laterals were constructed using 4-inch diameter slotted, corrugated, polyethylene pipe wrapped in a filter sock. Extraction wells were connected to a common, 4-inch diameter, 765-ft long, high-density polyethylene (HDPE) header pipe.

The air inlet wells each had a 30 ft long coil of black plastic pipe attached to the well. Ambient air first passed through the coiled pipe to warm the air by solar radiation before it entered the well.

Figure 1 shows a plan view of the design of the vapor extraction and air inlet wells at Seymour. Figure 2 shows a cross-section view of the design for the wells. Wells were spaced approximately 50 ft apart and a multimedia cap was constructed above the wells.

During installation of the SVE system, five lateral extraction wells were damaged. Repair of these wells was not feasible because of

Description of the Treatment System (cont.)

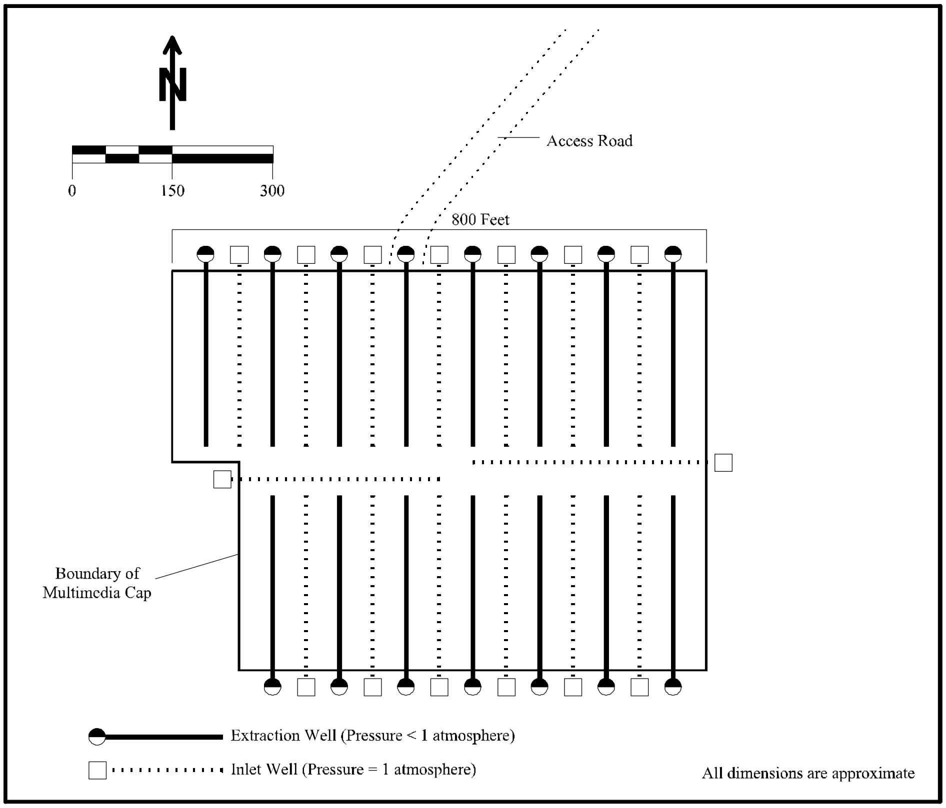

Figure 1. Plan View of the Design for the SVE Wells [1]

possible cap damage; therefore, the damaged wells were converted to fresh-air inlet wells.

Air inlet wells were maintained at atmospheric pressure and extraction wells maintained at less than atmospheric pressure. This configuration resulted in ambient air entering the inlet wells at atmospheric pressure, being drawn through the unsaturated zone, and then being exhausted through the subatmospheric-pressure extraction wells. With the exception of the five damaged wells described above, all wells were designed to be able to operate as either extraction or inlet wells. Each extraction well was retrofitted to accept a wind-driven turbine ventilator.

The vacuum blower used in this system is a 3-horsepower (HP) belt-driven model originally designed to deliver 40 standard cubic feet per minute (scfm) at 27 inches of water. However, the blower actually operated at an average of 6 to 100 scfm, with higher flow rates in the summer (100 scfm) and lower flow rates in the winter (30 scfm). The blower is housed in a fiberglass building on the north-central portion of the site.

A multimedia cap was constructed over the horizontal SVE wells at Seymour. The design of the cap included (from top to bottom) a 24-inch vegetative cover, geotextile fabric, a 12-inch thick drainage layer, a 0.060-inch (60 mil) thick synthetic liner, a 2-ft thick clay/till layer,

Description of the Treatment System (cont.)

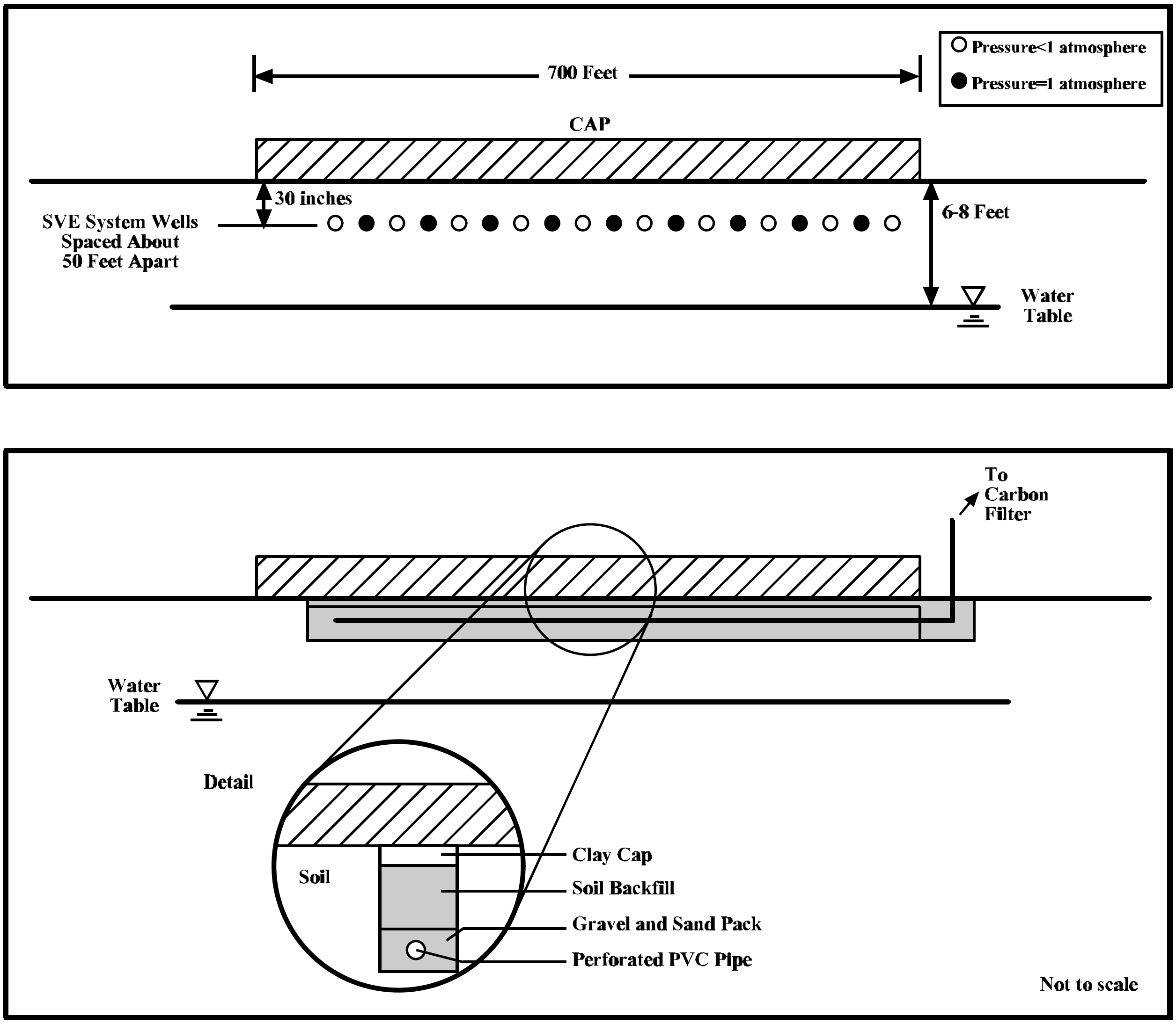

Figure 2. Cross Section of the Design for the SVE System Wells and Multimedia Cap [1]

DESCRIPTION OF THE TREATMENT SYSTEM (CONT.)

and another geotextile fabric. The cap was constructed in December 1990.

In situ bioremediation of contaminated soils was included as part of the remedy for this site because it was believed that not all of the compounds detected in soil at the site would be amenable to treatment using vapor extraction. Bioremediation was intended to be stimulated by the addition of nutrients to the soil prior to installation of the SVE system and cap. Nutrient addition was performed August to October 1986, January to February 1987, and July to August 1990 by mechanical injection and tilling of nutrients 18-24-inches below grade. One tanker-truck load of nutrient solution was added to the soil (5 - 10,000 gallons), consisting of nitrogen, phosphorus, potassium, and sulfur fertilizer.

System Operation [2, 4]

The design goal for the SVE system was to extract a total volume of soil vapor equal to 500 pore volumes from beneath the site within 30 years. The system was to be operated to extract between 2 and 35 pore volumes per year. After 500 pore volumes of soil vapor had been extracted, the system was to be operated as a passive system.

The design goal of extracting 500 pore volumes could be achieved after one or more temporary shutdowns. The system shut down active SVE operation 12/31/97 and is in the process of 1 year of passive activity (1/1/98 - 12/31/98). Passive operation is intended to allow build up of vapors under the clay cap and anaerobic bioremediation of chlorinated solvents in soil.

The system began operating in June 1992 at an average flow rate of 104 scfm. Samples were collected and analyzed for VOCs, semivolatile organic compounds (SVOC), and permanent gases that include oxygen, carbon dioxide, methane, carbon monoxide, and nitrogen. Permanent gas samples were collected to evaluate aeration and biological activity at the site.

Operating Parameters Affecting Treatment Cost or Performance

The key operating parameters that affect cost or performance for this technology, and the values measured for each, are provided below.

Table 3: Operating Parameters [5-8, 19]

Operating Parameter	Value
Air Flow Rate	52.9 to 122.6 cfm (average per quarter); 80 cfm (average over 2.8 years of operation)
Operating Vacuum	27 - 40 inches of water

Groundwater Pump-and-Treat System [11]

In addition to the remediation system for contaminated soil, an interim pump-and-treat system for contaminated groundwater was installed at the site in 1987. A permanent pump-and-treat system was completed in February 1991.

The pump-and-treat system at Seymour consists of two extraction wells located about 300 and 1,000 ft from the northern site boundary, with a combined pumping rate of approximately 140 gallons per minute (gpm). An additional well is located approximately 3/4 mile from the source area (at the far edge of the groundwater contamination plume), and is used only as a monitoring well. Extracted groundwater is treated on site with an iron reaction and settling system, air stripping, and additional filtering including activated carbon. The treated groundwater is discharged to the City of Seymour's Publicly-Owned Treatment Works (POTW).

DESCRIPTION OF THE TREATMENT SYSTEM (CONT.)

Timeline

Table 4: Timeline [4]

Start Date	End Date	Activity
1970	1980	Seymour Recycling Corporation and its predecessor, Seymour Manufacturing Company, processed, stored, and incinerated chemical wastes at the Seymour site.
1980	-	The site was placed under receivership by state court.
1982	-	A consent decree was signed by EPA and the PRPs requiring “surface cleanup.”
December 1982	January 1984	Surface cleanup was performed.
August 1983	May 1986	EPA conducted an RI at the site.
September 9, 1983	-	The site was listed on the NPL.
September 1986	-	The first ROD was signed for this site.
September 30, 1987	-	The second ROD was signed for this site.
December 1988	-	A Consent Decree outlining the Seymour site RD/RA cleanup was signed by EPA, IDEM, the City of Seymour, and approximately 150 PRPs.
July 1990	October 1990	The SVE system was constructed.
December 1990	-	The multi-media cap was constructed at the site.
June 1992	1997	The SVE system was operated.
1/1/98	12/31/98	The SVE system was shut down to allow the soils to return to an anaerobic state.

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [3]

No performance goals or standards for contaminated soil were identified in the ROD for this site. However, a design goal for the SVE system was to extract a total volume of soil vapor equal to 500 pore volumes within 30 years.

While no specific soil cleanup goals were included in the ROD, the ROD specified that groundwater be restored to attain a cumulative excess cancer risk of $1x10^{-5}$ at the site boundaries and a risk of $1x10^{-6}$ at the nearest current receptor, and to meet the MCLs at the site boundary for specific carcinogenic constituents including benzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethene, trichloroethene, and vinyl chloride. In addition, the ROD specified that the total health index (HI) not exceed 1, to account for the non-carcinogenic effects of contaminants in the groundwater using procedures specified in the Superfund Public Health Manual.

Treatment Performance Data [5-8]

Treatment performance data for this application, presented below, include the following: the concentration and mass of contaminants extracted from the soil and groundwater, the number of soil pore volumes extracted, the

TREATMENT SYSTEM PERFORMANCE (CONT.)

concentrations of “permanent” gases (oxygen, carbon monoxide, carbon dioxide, methane, and nitrogen) in the extraction system effluent, and the results from ambient air monitoring for VOCs and SVOCs.

SVE Performance Data [4, 5, 6, 7, 8, 11]

The vendor’s plan for collection and analysis of samples of extracted vapors was different for VOCs than for SVOCs. For VOCs, the vendor was to collect samples on a monthly basis from startup through June 1993 (1 year), on a quarterly basis through December 1993 (6 months), on a semiannual basis through September 1995 (2 years), and annually after that time for the duration of system operation. For SVOCs, the vendor was to collect samples on a quarterly basis from January 1993 to December 1993 (1 year), on a semiannual basis through December 1994 (1 year), and annually after that time for the duration of system operation.

The mass of VOCs extracted by the SVE and pump-and-treat systems are summarized on Table 5 for the period 1989 through 1996. The mass of VOCs was calculated as the sum of the masses of 48 specific constituents, as provided in References 5 through 8.

As shown on Table 5, the SVE system extracted a total of 29,166 pounds of VOCs (of an estimated 200,000 pounds) over a four and one-half year period from June 1992 to December 1996. The mass of VOCs extracted per year by the SVE system decreased by more than 90% over the four year period. Figure 3 summarizes the total mass of VOCs removed by the SVE system as a function of time. As shown on Figure 3, the total mass of VOCs removed is approaching an asymptotic value. The following VOCs accounted for approximately 85 percent of the total mass of VOCs extracted by the SVE system over the four year period: cis-DCE (8.7%), PCE (9.7%), toluene (4.8%), 1,1,1-TCA (31.8%), TCE (23.2%), and 1,1,2-Trichlorotrifluoroethane (freon) (7.0%).

Constituent-specific concentration data were available for nine VOCs in the vapors extracted from the vadose zone; concentrations ranged as follows during a four year period from 1993-1996:

Benzene - ND to 2 parts per million by volume (ppmv)
Carbon tetrachloride - ND to 1.5 ppmv
Chloroform - ND to 2 ppmv
1,2-Dichloroethane - ND to 6 ppmv
DCE - ND to 1.5 ppmv
Methylene chloride - ND to 2 ppmv
PCE - ND to 130 ppmv
TCE - ND to 600 ppmv
Vinyl chloride - ND to 8 ppmv

According to the EPA RPM, SVOCs have never been measured at concentrations above a level that was considered a risk to human health and the environment. EPA stopped sampling for SVOCs in 1995. SVOCs were analyzed for in 8 sampling events during 1992 and 1993 by collecting samples of extracted vapors in a Tedlar bag near the blower. SVOCs were measured as below detection limits (DL) in 4 of the 8 events. In the events where they were detected, concentrations included the following:

SVOCs	Concentrations Measured Above DL (mg/kg)
Naphthalene	0.6
Naphthalene	0.02
Nitrobenzene	0.07
2-Methyl Naphthalene	0.014
Butyl Benzyl Phthalate	0.065
Butyl Benzyl Phthalate	0.045
Bis (2-ethylhexyl) Phthalate	0.014

TREATMENT SYSTEM PERFORMANCE (CONT.)

Table 5: Mass of VOCs (lbs) Extracted By SVE and Groundwater Pump-and-Treat Systems [5, 6, 7, 8, 11]

Time Period	SVE System		Pump-and-Treat System	
	Mass per Time Period	Cumulative Mass	Mass per Time Period	Cumulative Mass
1989 – December 31, 1992*	15,019	15,019	1,081	1,081
January 1 – December 31, 1993	8,543	23,562	684	1,765
January 1 – December 31, 1994	3,741	27,303	491	2,256
January 1 – December 31, 1995	1,302	28,606	167	2,423
January 1 – July 31, 1996	162	28,768	342	2,765
August 1 – December 31, 1996**	398	29,166	Not Provided	Not Provided

* SVE system operation began on June 9, 1992
** Derived from Ref. 11, p. 5

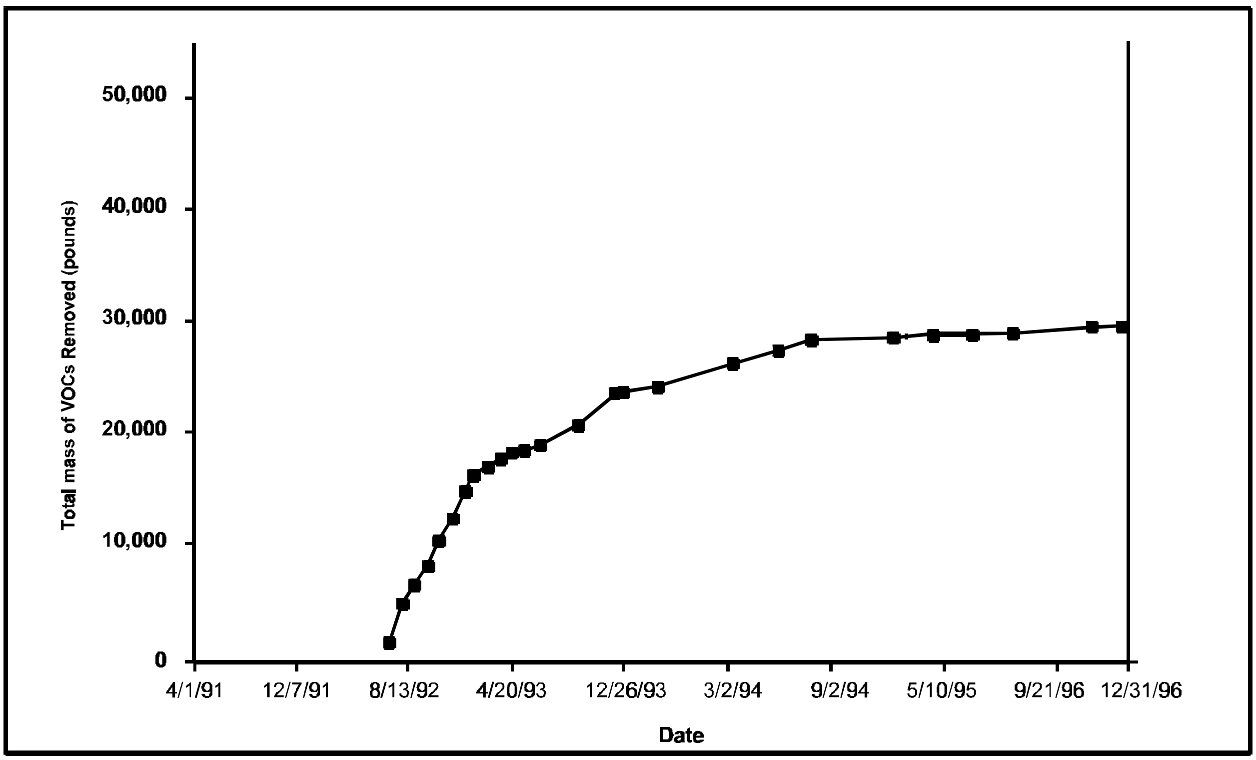

Figure 3. Total Mass of VOCs Removed by SVE System Over Time [5-8]

Treatment System Performance (cont.)

Table 6 summarizes information about the number of pore volumes extracted by the SVE system from startup through December 31, 1997 (2.8 years of operation). Almost 430 pore volumes were extracted during this period (a pore volume at this site is equal to 460,000 cubic feet). The number of pore volumes extracted per quarter ranged from as high as 35 (3rd quarter 1992) to 15 (1st quarter 1994). Also as shown on Table 6, the average flow rate for the SVE system at this site ranged from 122.6 cfm to 52.9 cfm over this time period.

Permanent gases were analyzed using samples collected in Tedlar bags. Methane was detected at concentrations as high as 7.8 percent at startup, at concentrations of less than 0.1 percent after completing two months of system operation (August 1992), and has remained at that lower concentration since that time. Carbon dioxide was detected at concentrations as high as 9.5 percent at startup, at concentrations of less than 0.1 percent after 9 months of operation (March 1993), and has remained at that lower concentration since that time. The concentration of oxygen was measured as low as 3.6 percent at startup, increased to atmospheric levels (21 percent) after 4 months of operation (October 1992), and has remained at this elevated concentration since that time.

Table 6: Number of Pore Volumes Extracted by SVE System [6, 11, 18]

Integrating Period	Starting Date	Ending Date	Flow Average (cfm) [1]	Number of Pore Volumes Removed [2]
Startup	06/09/92	06/30/92	121.8	8.0
3rd Quarter 1992	07/01/92	09/30/92	122.6	34.9
4th Quarter 1992	10/01/92	12/31/92	101.2	28.8
1st Quarter 1993	01/01/93	03/31/93	85.7	24.1
2nd Quarter 1993	04/01/93	06/30/93	103.5	29.5
3rd Quarter 1993	07/01/93	09/30/93	78.3	22.5
4th Quarter 1993	10/01/93	12/31/93	64.8	18.7
1st Quarter 1994	01/01/94	03/31/94	52.9	14.9
2nd Quarter 1994	04/01/94	06/30/94	61.5	17.5
3rd Quarter 1994	07/01/94	09/30/94	88.7	25.6
4th Quarter 1994	10/01/94	12/31/94	62.5	18.0
1st Quarter 1995	01/01/95	03/31/95	60.0	16.9
2nd and 3rd Quarters 1995	4/1/95	9/30/95	85	30
4th Quarter 1995	10/1/95	12/31/95	75	10
1st and 2nd Quarters 1996	1/1/96	6/30/96	37.5	40
3rd and 4th Quarters 1996	7/1/96	12/31/96	53	40
1st and 2nd Quarters 1997	1/1/97	6/30/97	27	13
3rd and 4th Quarters 1997	7/1/97	12/31/97	76.5	36
Total (through 12/31/97)				427

[1] SVE flowrate recorded by flow sensor and data logging system flow totalizer.
[2] One pore volume is equal to approximately 460,000 cubic feet.

Treatment System Performance (cont.)

These concentrations of permanent gases indicate that, at startup, the vadose zone was in an anaerobic state, with low concentrations of oxygen but high concentrations of methane and carbon dioxide. However, after several months of system operation, these data show that the vadose zone became aerobic, with atmospheric concentrations of oxygen. Aerobic conditions were identified by the vendor as important for minimizing decomposition of DCE, TCE and PCE and for promoting aerobic biodegradation.

Ambient air samples were collected during initial system startup and during long-term operations (the first annual sampling took place in July 1994.) These samples were collected during the summer from a sampling station located down-wind from the site. According to the vendor, samples were collected during the summer because that is when the greatest chance for volatilization and low wind conditions are likely to occur. The vendor indicated that quarterly samples of ambient air showed concentrations of VOCs in the 1 - 2 ppb range, that no SVOCs were detected, and that most compounds that were detected were not related to operations at the site. According to the vendor, these results support their conclusion from a risk assessment that no adverse impacts to the ambient air have resulted from the site operations.

Pump-and-Treat Performance Data [5, 6, 7, 8, 11, 14, 18]

Table 5 also shows the mass of VOCs extracted from the groundwater using the pump-and-treat system, and compares the mass of VOCs extracted by SVE with the mass extracted from the saturated zone using a pump-and-treat system. As Table 5 shows, the pump-and-treat system extracted a total of 2,765 pounds of VOCs over a seven year period from 1989 to 1996. The SVE system extracted approximately ten times more mass of VOCs from the vadose zone than the pump-and-treat system extracted from the saturated zone.

According to the EPA RPM, as of December 1997, approximately 30,000 pounds of organics have been extracted from the vadose zone with the SVE system, while only approximately 5,000 pounds have been extracted from the groundwater using the pump-and-treat system.

According to EPA's Five-Year Review Report, monitoring of the groundwater extraction and treatment system indicates that containment and reduction of contaminant concentrations in the groundwater has been achieved at this site. However, this report states that the size of the plume has not been reduced and has "expanded through dilution and groundwater flow at some locations." The PRPs at this site are required to operate the pump-and-treat system for a minimum of 12 years and to meet drinking water standards.

Performance Data Quality

A written quality assurance (QA) plan and construction QA plan (CQAP) were prepared by Canonie Environmental Services, Inc. (CES), and approved by EPA prior to the start of SVE system construction. In addition, a construction quality control (QC) plan was prepared and followed by CES. QA procedures were developed for each phase of preconstruction, construction, and postconstruction activities. No exceptions to QA/QC procedures were noted in the available references.

TREATMENT SYSTEM COSTS

Procurement Process

The PRP's contracted with G&M of Plainview, New York, to design and implement the remedy.

Treatment System Cost [16]

Table 7 summarizes the construction and operation and maintenance (O&M) costs for the overall remedial activity at Seymour. Actual costs are provided for project inception through 1991, and projected expenditures from 1992 through 1997; this table shows costs for all remedial activities at Seymour, including soil and groundwater cleanups. As shown in Table 7, approximately $23 million were expended at Seymour from inception through 1991, and approximately $7 million were projected as expenditures from 1992 through 1997, for a total of approximately $30 million from inception through 1997.

Table 7: Remedial Costs for Seymour [16]

Item	Actual Expenditure - Inception Through 1991 ($ million)	Projected Expenditures 1992 Through 1997 ($ million)	Total Projected Expenditures Inception Through 1997 ($ million)*
Construction Subcontracts (cap, site development, well installation, vapor extraction system, bioremediation, pretreatment plants, sediment removal, building demolition, Elk's Club alternate water supply)	8.71	0.43	9.14
Engineering/Technical Support (cap, site development, well installation, vapor extraction system, air monitoring/risk assessment, bioremediation, pretreatment plants, sediment removal, building demolition, Elk's Club alternate water supply)	4.91	0.19	5.10
Operation and Maintenance (consultant charges, wages/salaries, lab costs, maintenance, utilities, chemical/supplies)	2.20	3.57	5.77
Trust Administration	0.50	0.58	1.08
Agency Oversight	0.46	0.89	1.35
Contingency **	0.00	1.00	1.00
Past Response Actions ***	6.50	0.00	6.50
TOTAL	23.28	6.66	29.94

* Total Projected Cost Through 1997 includes actual expenditures through 1991 plus projected expenditures 1992 through 1997

** Contingency costs as projected by PRPs

*** Past response actions are for payments made after formation of the PRP Trust for response costs incurred by EPA and the Coast Guard before trust cleanup activities were begun

TREATMENT SYSTEM COSTS (CONT.)

Actual costs for operation and maintenance of the overall remedial action at Seymour are further detailed in Table 8. Table 8 shows actual costs for the elements that are included for each year from 1992 through 1997. As shown in Table 8, the total for actual costs for operation and maintenance was $3,474,610.

As shown in Table 8, annual O&M costs for the first four years of system operation averaged approximately $750,000 per year, while annual O&M costs for the latter two years of system operation averaged approximately $220,000, less than one-third as much as for the first four years. The O&M costs decreased substantially in the latter two years of system operation because of the relatively lesser amount of time required for document preparation, sampling, data evaluation, and other activities. In addition, since 1995 EPA has had no ARCS/RAC contractors at this site.

Table 8: Actual Operation and Maintenance Costs - Overall Remedial Action at Seymour [12]

Sub Item	1992	1993	1994	1995	1996	1997 Through September	Total
Consultant Charges (operations support, SVE and P&T well maintenance, air modeling, SVE exhaust monitoring, air quality monitoring, risk assessment, sampling, modeling/ pumping restrictions, extraction optimization, project administration) Consultant Charges	$293,322	$272,874	$199,211	$112,178	$72,159	$29,918	
Wages/Salaries (wages, secretarial services, engineering/purchasing, travel	124,555	148,058	133,187	65,943	47,175	23,399	
Laboratory Costs (laboratory, sample analysis, SVE monitoring, air quality monitoring, laboratory/freight)	148,852	105,115	83,165	52,907	26,520	44,925	
Maintenance (new equipment, maintenance, replacement parts, drillers, monitoring well replacement, painting/security)	74,574	58,139	99,283	37,831	42,569	21,133	
Utilities (electrical, gas, potable water, telephone)	36,634	34,856	28,432	18,308	15,889	11,632	
Chemical/Supplies	8,201	3,931	7,948	16,039	9,202	7,228	
Trust Administration (local water payments, legal expenses, bank fees, outside auditors, trustee's fees)	65,495	62,070	74,940	110,429	45,179	29,549	
Agency Oversight (EPA, Illinois DEM)	123,203	277,184	33,560	121,246	12,357	4,106	
TOTAL	$874,836	$962,227	$659,726	$534,881	$271,050	$171,890	$3,474,610

TREATMENT SYSTEM COSTS (CONT.)

Table 9 shows only that portion of the total remedial costs that are due to the soil remediation at Seymour. As shown in Table 9, the expenditures for a vapor extraction system were $1,200,000, consisting of $320,000 for construction and $900,000 for engineering/technical support.

According to the EPA RPM, unit costs for SVE would be difficult to identify for this application, because of the complex series of activities that have taken place at this site in the past, and the relatively large amount of money expended on groundwater pump-and-treat compared with SVE. The RPM indicated that SVE is fairly inexpensive to operate and that blowers used in SVE require very little in O&M (e.g., electricity) as compared with pumps used in groundwater pump-and-treat.

Table 9: Estimated Costs for Soil Remediation at Seymour [16]

Cost Element	Cost ($ in 1991)
Capital	
Equipment and Construction	
- Vapor extraction system	$320,000
- Bioremediation	$520,000
- Cap (including all site development)	$4,840,000
Engineering/Technical Support	
- Vapor extraction system	$900,000
- Bioremediation	$200,000
- Cap (including all site development)	$1,580,000
Capital Subtotal	**$8,360,000**
Operation and Maintenance	**Information not available**
TOTAL	**Information not available**

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

Approximately $8.4 million was expended for capital equipment, construction, and engineering/technical support for soil remediation, including $1,200,000 for construction of the SVE system. However, information was not provided to identify how much was expended for O&M of the SVE system, separate from the O&M for the total remedial activity at Seymour. Therefore, a unit cost for construction and O&M of the SVE system was not calculated for this application.

The total cost for remedial activities at Seymour was approximately $30,000,000, from inception through 1997. This amount includes costs for construction and operation of the SVE system, bioremediation, sediment removal, and groundwater pump-and-treat system.

Performance Observations and Lessons Learned

No performance goals were established for soil at this site, however design goals were established for the total number of pore volumes to be extracted and the number of pore volumes to be extracted on a yearly basis. As of 1997, approximately 430 pore volumes had been extracted, as well as nearly 30,000 pounds of VOCs. For 1993 and 1994 (the two years for which a full year's worth of data are available), the SVE system extracted 76 and 91 pore volumes per year, respectively.

Analytical data from the vadose zone showed that at start-up the vadose zone was in an anaerobic state, with low concentrations of oxygen and high concentrations of methane and carbon dioxide. However, after several months of system operation, the vadose zone became aerobic, thus minimizing the decomposition of DCE, TCE, and PCE.

Other Observations and Lessons Learned

This application was unusual because the SVE system was installed using horizontal wells in a very shallow vadose zone (less than 10 ft) and was covered with a multimedia cap to prevent short circuiting of air flow in the subsurface.

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Preparation of Analysis

This case study was prepared for the U.S. Environmental Protection Agency's (EPA) Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Tetra Tech EM Inc. under EPA Contract No. 68-W4-0004.